Enhancements to the CALIOP aerosol subtyping and lidar ratio selection algorithms for Level II version 4.

LIDAR SCIENCE WORKING GROUP

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Summary

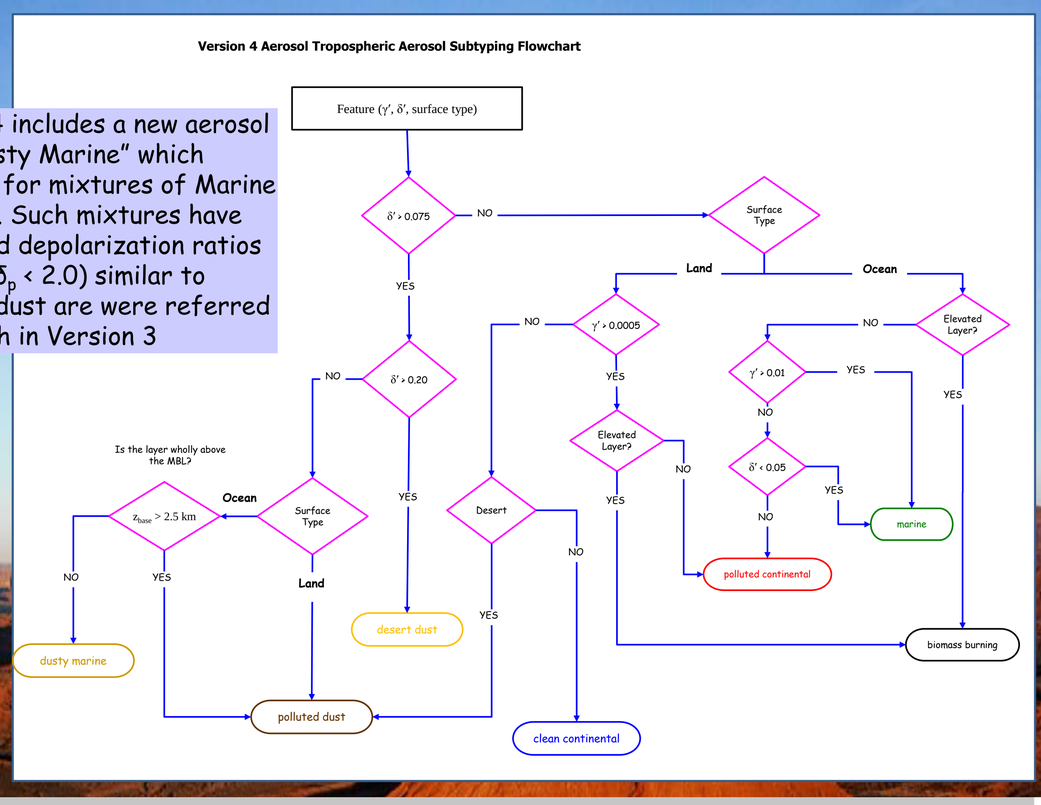
- Revised tropospheric lidar ratios
- Definition of a new aerosol type – 'dusty marine'.
- Definition of elevated layers
- Definition of fringes and implementation of the Subtype Coalescence Algorithm for AeRosol Fringes (SCAARF)

1. Tropospheric Aerosol 532 nm Lidar Ratios

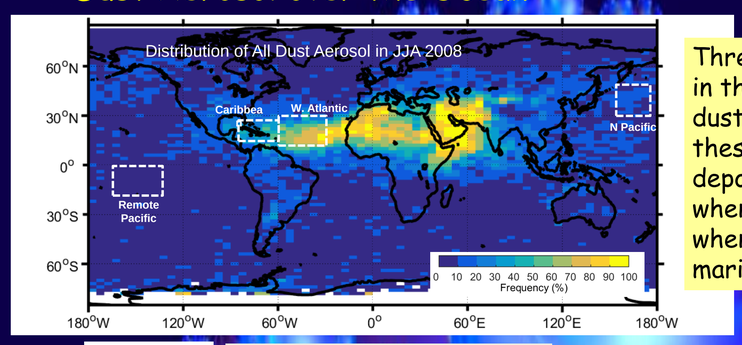
Aerosol Subtype	Version 4 Lidar Ratio (sr)	Version 3 Lidar Ratio (sr)
Biomass Burning	70	70
Clean Continental	**53**	35
Clean Marine	**23**	20
Dust	**44**	40
Dusty Marine	**37**	N/A
Polluted Continental	70	70
Polluted Dust	55	55

2. Definition of a new aerosol type – "dusty marine"

Version 4 includes a new aerosol type "Dusty Marine" which accounts for mixtures of Marine and Dust. Such mixtures have estimated depolarization ratios ($0.075 < \delta_p < 2.0$) similar to polluted dust are were referred to as such in Version 3

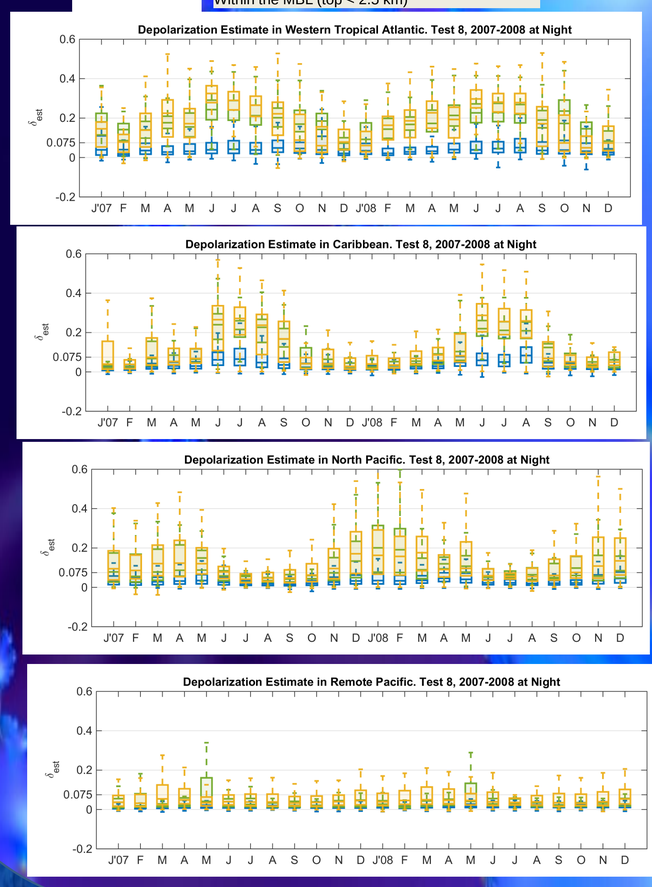


3. Defining Elevated Layers and the Altitude of Mixing for Dust Aerosol over the Ocean



Three regions with dust deposition in the MBL and one region without dust are shown. The time series for these regions shows how estimated depolarization ratio (EDR) changes when dust mixes into the MBL and when CALIOP detects dust above marine aerosol as a single layer.

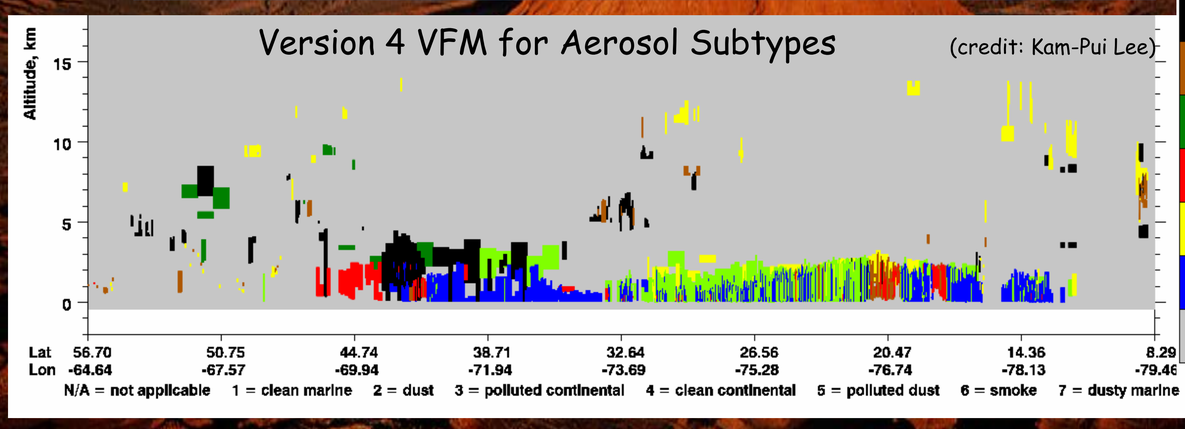
Above the MBL (base >2.5 km)
Mixed with the MBL (top > 2.5 km, base < 1.5 km)
Within the MBL (top < 2.5 km)



- In the western tropical Atlantic, EDR is higher above the MBL during most of the year besides winter. There is a slight increase in EDR within the MBL during summer months.
- In the Caribbean, EDR is elevated above and within the MBL Jun-Sept. corresponding to the months of maximum Saharan dust emission
- In the N. Pacific (east of Asia), EDR above the MBL is elevated in winter/spring months, corresponding to the months of maximum Asian dust emission. The distributions overlap within the MBL.
- In the remote Pacific, EDR is below 0.075, especially within the MBL which is expected since clean marine dominates the distribution at this location.

The EDR increase above and within the marine boundary layer is enough to discriminate between dusty marine and marine in most locations

Version 4 VFM for Aerosol Subtypes (credit: Kam-Pui Lee)



Also note in Version 4, in cases where polluted continental cannot be discriminated from smoke, the VFM will report "polluted continental or smoke" and assign identical lidar ratios to such layers

4 a. Definition of fringes and implementation of the Subtype Coalescence Algorithm for AeRosol Fringes (SCAARF)

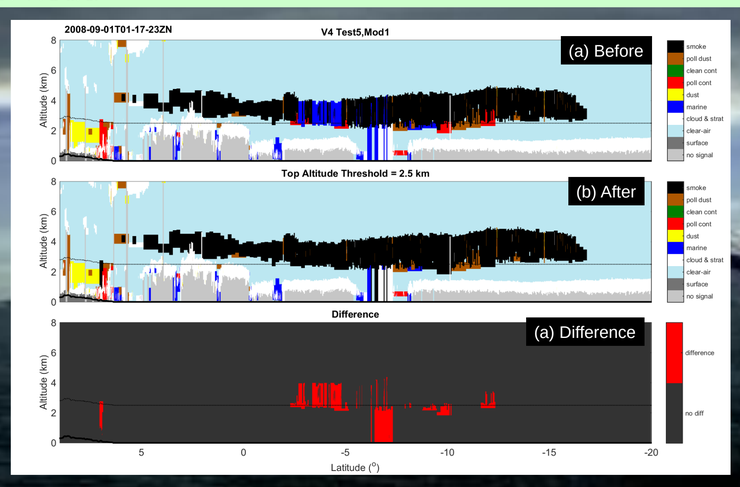
The aerosol subtyping algorithm classifies aerosol layers as smoke if they are elevated. In Version 3, the definition of elevated relied upon detachment of the aerosol base from the surface amongst other thickness and top altitude requirements. We have revised the definition of "elevated" in Version 4 to identify layers whose tops are elevated beyond the surface-attached boundary layer. Furthermore, "fringes" of aerosol plumes that are detected at 20 km or 80 km horizontal resolution at the plume base tend to be often misclassified. These fringes are detected at coarse resolution due to overlying attenuation and subsequent aerosol subtyping may not be as reliable as that of the adjacent higher-resolution layers overhead. SCAARF re-classifies the aerosol subtype of these lower fringes to the dominant subtype of the adjacent overlying layers. Below are examples of before and after application of these algorithms which show these enhancements.

4 b. Definition of fringes and implementation of the Subtype Coalescence Algorithm for AeRosol Fringes (SCAARF)

Fringes of features tend to occur at the base of moderate to strongly attenuating layers. While the overlying layers are detected at 5 km resolution, enough signal attenuation has occurred that the lowest portion of the layer is detected at a coarser resolution.

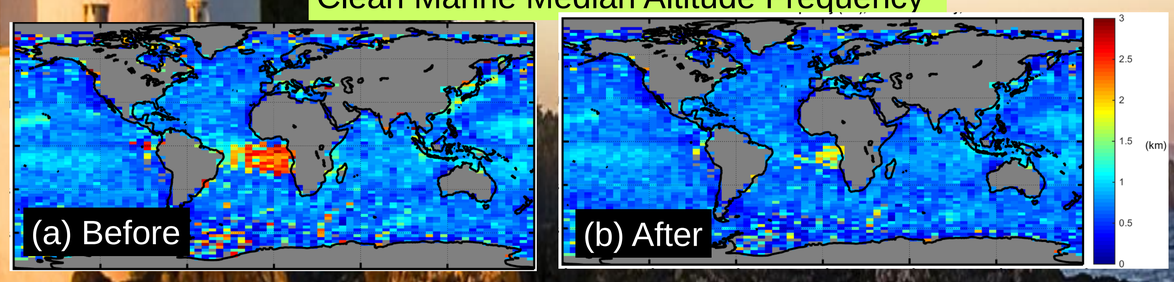
- Only 20 km and 80 km resolution aerosol layers are fringes.
- Fringes must be adjacent to aerosol layers overhead at higher resolutions.
- The number of adjacent aerosol layers overhead must account for 50% or more of the horizontal extent of the fringe-candidate layer after removing higher resolution features.
- Fringes are re-assigned to the most frequent subtype of the overlying adjacent aerosol layers
- Fringes are not adjacent to aerosol layers at 5 km, 20 km or 80 km resolution along their base.
- Fringes can be adjacent to clouds along their base at any resolution. However, 5 km and coarser resolution clouds must be high-confidence (CAD score > 70).
- Fringe bases must be 240 meters above the local surface elevation.

Fringes are re-typed to match dominant subtype of adjacent layers overhead



Note the elevated marine layers in (a) more plausibly classified as smoke in (b)

Clean Marine Median Altitude Frequency



A significant fraction of the elevated layers shown in (a) off the coast of W. Africa misclassified as 'marine' in version 3 are now correctly classified as 'smoke' in version 4

Summary

Version 4 includes several enhancements to the subtyping algorithm. These include:

(a)The definition of a dusty marine type to account for a significant fraction of layers previous misclassified as polluted continental

(b)The implementation of new elevated layer that will provide better estimates of above cloud smoke aerosol distributions

(c)The implementation of SCAARF to reclassify the aerosol subtype of lower fringes to the dominant subtype of the adjacent overlying layers. This will significantly reduce instances of striping (piano effect) and aerosol type distributions within and above the boundary layer

(d)Enhanced lidar ratios reflecting recent understanding